
REPORT No. 236

TESTS ON AIRPLANE FUSELAGES, FLOATS AND HULLS

By WALTER S. DIEHL
Bureau of Aeronautics, Navy Department

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SUMMARY

This report is a compilation of test data on airplane fuselages, nacelles, airship cars, seaplane floats, and seaplane hulls, prepared by the Bureau of Aeronautics, at the request of the National Advisory Committee for Aeronautics. The discussion of the data includes the derivation of a scale correction curve to be used in obtaining the full scale drag. Composite curves of drag and L/D for floats and hulls are also given.

INTRODUCTION

In order to make an accurate estimate of the probable performance of an airplane, the parasite drag must be known. When wind tunnel test data are not available, this parasite drag must be obtained by some process of summation, and in such a process one of the largest and most uncertain items is the drag of the fuselage, or similar parts, such as the nacelles, hull, or floats. The usual practice is to compare the desired design with other and similar designs for which test data are available.

In 1922 the Bureau of Aeronautics compiled all of the wind tunnel test data then available on fuselages, hulls, nacelles, and floats, into a form which was convenient for ready reference. This compilation was of such value that the National Advisory Committee for Aeronautics has seen fit to request its release for publication as the first of a series of reports, giving wind tunnel test data of this type in condensed form.

For convenience in reference the models have been divided into seven groups, each designated by a letter as follows:

- A.—Airplane fuselages.
- B.—Airplane fuselages with appendages.
- C.—Nacelles.
- D.—Fins.
- E.—Airship cars.
- F.—Seaplane floats.
- G.—Seaplane hulls.

Each model is designated by a group letter and a number, thus A1, i. e., airplane fuselage No. 1, or F4, float No. 4.

TEST DATA

For each model the source of the test data, the size of the model, and the test speed are given in addition to the test data. Whenever practical, the drag is given in pounds and pounds per square foot at some specified wind speed.

The data from British tests are frequently in the form of normal force Z and longitudinal force X . When necessary these can be converted to lift and drag by the usual formulas:

$$L = Z \cos \theta - X \sin \theta \quad (1)$$

$$D = X \cos \theta + Z \sin \theta$$

Where θ is the angle of pitch.

Corrections for pressure drop along the wind tunnel axis have not been applied to any of the test data in this report. Since it would rarely be more than the experimental error, the omission of this correction is apparently justified for all models which deviate appreciably from the conventional streamline forms. For example, on the float F1 the maximum possible correction for pressure drop at 58.7 f. p. s. is about 0.0007 pound, while the actual correction is somewhat less, due to location of model during tests. Since the measured drag of F1 at 58.7 f. p. s. was 0.0627 pound, the correction would be of the order of 1 per cent.

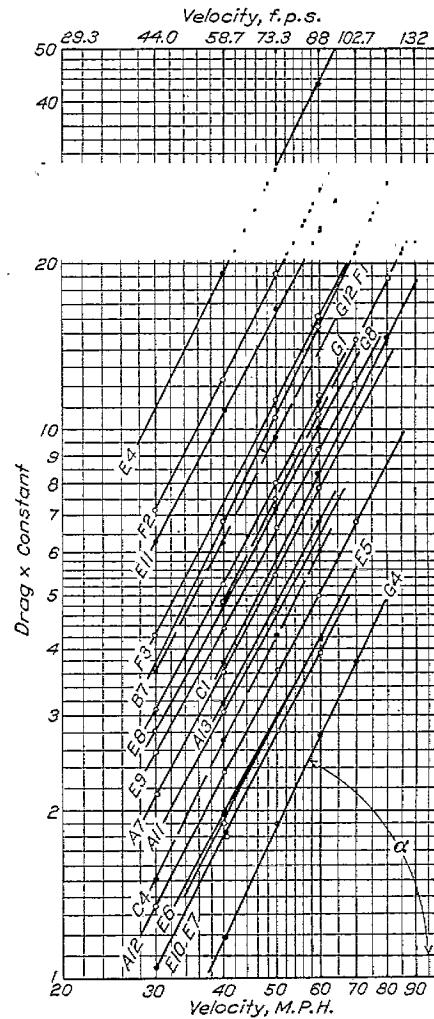


FIG. I

SCALE EFFECT

Taking the product of the velocity V by some characteristic length l as the "scale" the lift may be assumed to vary as the square of the scale. That is:

$$L = K_L (V\ell)^2 \quad (3)$$

where K_L is a constant for each model.

The drag does not vary as the square, but as some lesser power of the scale. Figure 1 is a logarithmic plot of drag against speed for all models tested at more than one speed. The slopes of the lines with the corresponding exponents are given in the following table:

VELOCITY EXPONENT IN THE DRAG EQUATION

$$D = KV^n$$

Model designation	α	n $\tan \alpha$
A7.....	61.7	1.86
A11.....	61.3	1.86
A12.....	62.2	1.90
A13.....	61.6	1.85
B7.....	63.7	2.02
C1.....	62.7	1.94
C4.....	63.0	1.96
E4.....	63.0	1.96
E5.....	61.0	1.80
E6.....	61.8	1.86
E7.....	62.3	1.90
E8.....	61.8	1.86
E9.....	61.4	1.91
E10.....	62.3	1.90
E11.....	61.8	1.86
F1.....	62.7	1.94
F2.....	62.3	1.90
F3.....	62.4	1.91
G1.....	61.8	1.86
G4.....	64.0	2.05
G8.....	61.2	1.82
G11.....	62.5	1.92
G12.....	62.7	1.94
Average.....	62.2	1.90

The average value of the exponent so found is $n = 1.90$. While this strictly applies to the velocity only, it may be assumed for variation in length also. The drag equation may therefore be written as

$$D = K_D (Vl)^{1.9} \quad (4)$$

where K_D is a constant for each model.

It will probably be found more convenient to use instead of equation (4):

$$D = K_s D_m \left(\frac{Vl}{V_m l_m} \right)^2 \quad (5)$$

where K_s is the scale correction factor given on Figure 2, D_m the observed model drag at $V_m l_m$ and D the full scale drag at Vl .

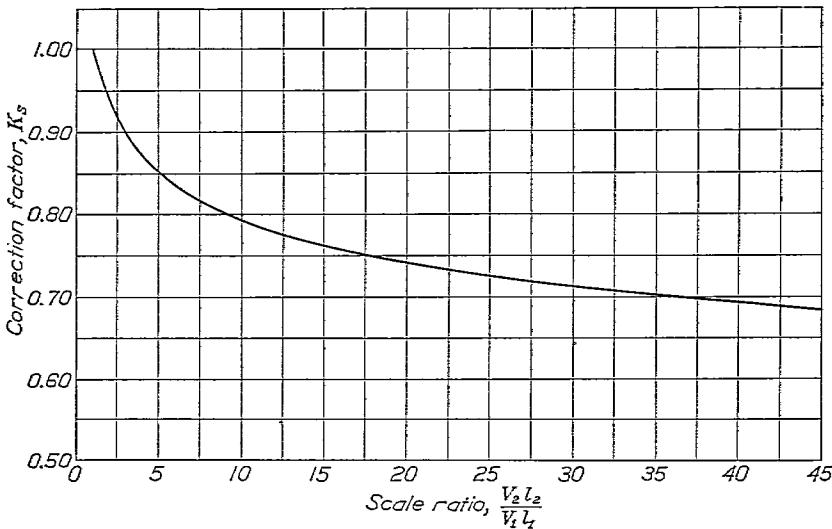


FIG. 2.—Drag correction factors for fuselages, hulls, floats, etc. Based on the assumption that $D \propto V^{1.9}$
 $D_s = K_s D_m \left(\frac{V_2 l_2}{V_1 l_1} \right)^2$ Where D_s = Drag at $V_2 l_2$ and D_m = Drag at $V_1 l_1$

In converting model data to full scale values, any length on the model such as maximum diameter, overall length, etc., may be used to determine the scale, provided that the same geometrical length is used for model and full scale. The use of overall length is recommended, however.

The square of a length has the dimensions of area so that the maximum cross-sectional area may be used instead of l^2 if desired.

COMPOSITE CURVES FOR FLOATS AND HULLS

The drag curves for different floats and hulls differ so little, one from another, that a composite curve may be drawn to represent within comparatively narrow limits the drag for all

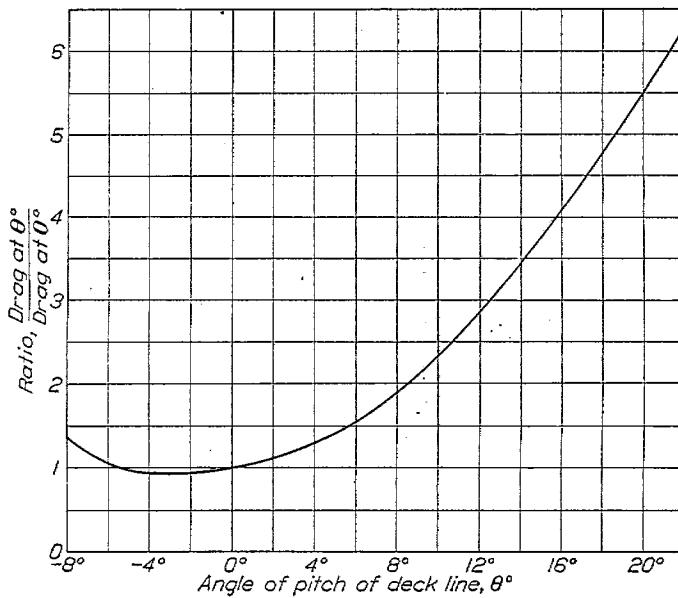


FIG. 3.—Composite resistance curve for seaplane floats and hulls

such models. This curve is given on Figure 3. Knowing the drag for 0° pitch of the deck line, the drag for any normal pitch angle is readily obtained from this curve.

The lift curves are also similar, so that a composite curve for L/D may be drawn as in Figure 4.

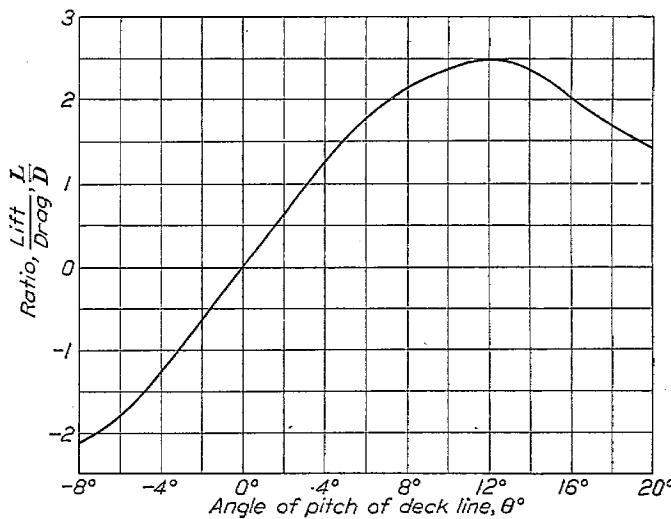
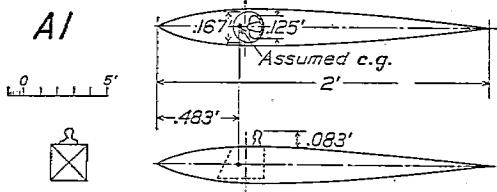
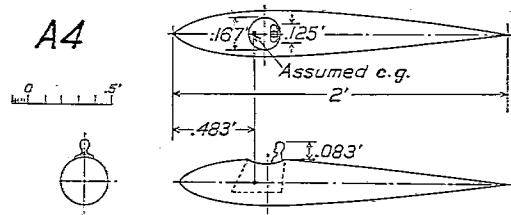


FIG. 4.—Composite L/D curve for floats and hulls

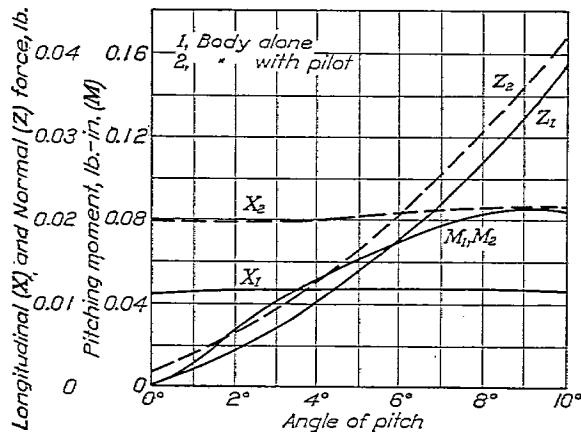
The curves of Figures 3 and 4 apply to any form which approximates to a streamline and which does not have too many appendages. From the limited data available there is reason to believe that the same, or at any rate similar, curves will apply to all body lines of the average or better types.



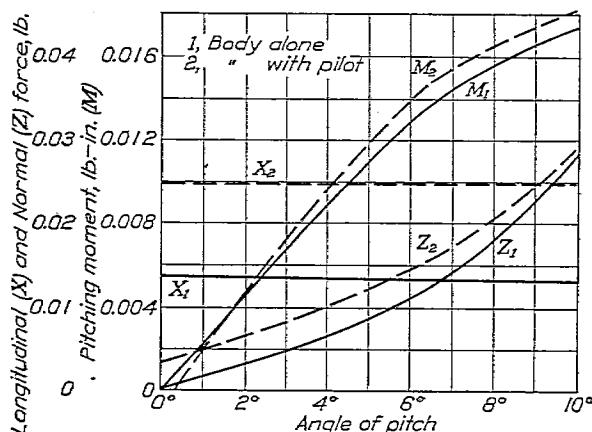
$$1 \left\{ \begin{array}{l} 0^\circ \text{ pitch and yaw} \\ V, \text{ f.p.s.} \quad .40 \\ D, \text{ lb.} \quad .0114 \\ D/S, \text{ lb./sq.ft.} \quad .2505 \end{array} \right. \quad 2 \left\{ \begin{array}{l} V, \text{ f.p.s.} \quad .40 \\ D, \text{ lb.} \quad .0197 \\ D/S, \text{ lb./sq.ft.} \quad .4330 \end{array} \right.$$



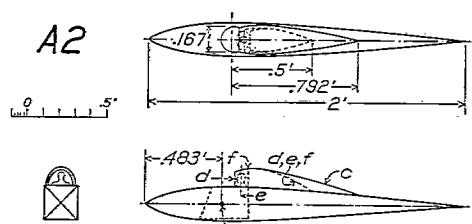
$$1 \left\{ \begin{array}{l} 0^\circ \text{ pitch and yaw} \\ V, \text{ f.p.s.} \quad .40 \\ D, \text{ lb.} \quad .0134 \\ D/S, \text{ lb./sq.ft.} \quad .2094 \end{array} \right. \quad 2 \left\{ \begin{array}{l} V, \text{ f.p.s.} \quad .40 \\ D, \text{ lb.} \quad .0236 \\ D/S, \text{ lb./sq.ft.} \quad .3688 \end{array} \right.$$



Forces and moments in pitch on an airplane fuselage. $V=40$ f. p. s.
(Ref. R. and M. No. 112)

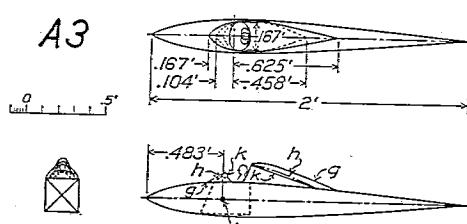


Forces and moments in pitch on an airplane fuselage $V=40$ f. p. s.
(Ref. R. and M. No. 112)



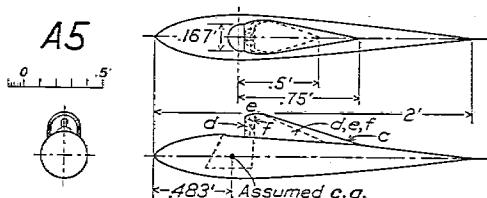
$$\begin{aligned} 0^\circ \text{ pitch and yaw } & V=40 \text{ f.p.s.} & D, \text{ lb.} \\ a, \text{ Model without wind shield or pilot} & - & .0114 \\ b, " \text{ with pilot, no wind shield} & - & .0197 \\ c, " \text{ long wind shield off} & - & .0254 \\ d, " \text{ short} & - & .0257 \\ e, " \text{ " " " front cut back to e} & - & .0217 \\ f, " \text{ " " " " f} & - & .0255 \end{aligned}$$

Drag on an airplane fuselage. $V=40$ f. p. s. (Ref. R. and M. No. 112)



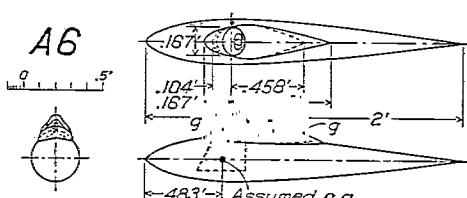
$$\begin{aligned} 0^\circ \text{ pitch and yaw } & V=40 \text{ f.p.s.} & D, \text{ lb.} \\ g, \text{ Model without wind shield or pilot} & - & .0114 \\ h, " \text{ with pilot, no wind shield} & - & .0197 \\ g, " \text{ " wind shield "g-g"} & - & .0206 \\ h, " \text{ " " "h-h"} & - & .0242 \\ k, " \text{ " " "k-k"} & - & .0335 \end{aligned}$$

Drag on an airplane fuselage. $V=40$ f. p. s. (Ref. R. and M. No. 112)



$$\begin{aligned} 0^\circ \text{ pitch and yaw } & V=40 \text{ f.p.s.} & D, \text{ lb.} \\ a, \text{ Model without wind shield or pilot} & - & .0134 \\ b, " \text{ with pilot, no wind shield} & - & .0246 \\ c, " \text{ long wind shield off} & - & .0256 \\ d, " \text{ " " " front cut back to e} & - & .0252 \\ e, " \text{ " " " " f} & - & .0272 \\ f, " \text{ " " " " " f} & - & .0296 \end{aligned}$$

Drag on an airplane fuselage. $V=40$ f. p. s. (Ref. R. and M. No. 112)

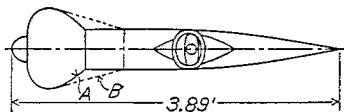


$$\begin{aligned} 0^\circ \text{ pitch and yaw } & V=40 \text{ f.p.s.} & D, \text{ lb.} \\ a, \text{ Model without wind shield or pilot} & - & .0134 \\ b, " \text{ with pilot, no wind shield} & - & .0246 \\ g, " \text{ " wind shield "g-g"} & - & .0225 \\ h, " \text{ " " "h-h"} & - & .0242 \\ k, " \text{ " " "k-k"} & - & .0272 \end{aligned}$$

Drag on an airplane fuselage. $V=40$ f. p. s. (Ref. R. and M. No. 112)

A7

0 1 2 3 4 5'

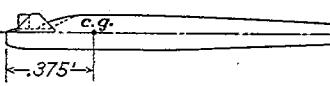
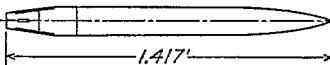


0° pitch and yaw	$V, f.p.s.$	44.0	58.7	73.3	88.0
Original model "A"	$D, lb.$	.2850	.4750	.7280	1.0150
$S = .6750 \text{ sq. ft.}$	$D/S, lb./sq.ft.$	.4222	.7037	1.0785	1.5037
Fairing "B" added	$D, lb.$	.2150	.3630	.5460	.7830
$S = .6750 \text{ sq. ft.}$	$D/S, lb./sq.ft.$	.3185	.5378	.8089	1.1600
Fairing "C" removed	$D, lb.$	.2000	.3420	.5250	.7450
$S = .6620 \text{ sq. ft.}$	$D/S, lb./sq.ft.$	.3021	.5166	.7931	1.1254

Drag on a Navy speed scout seaplane fuselage. (Ref. W. T. R. No. 20)

A8

0 1

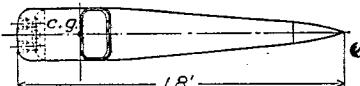


$$S = .0173 \text{ sq. ft.}$$

0° pitch and yaw	$V, f.p.s.$	40
	$D, lb.$	.0159
	$D/S, lb./sq.ft.$	.9200

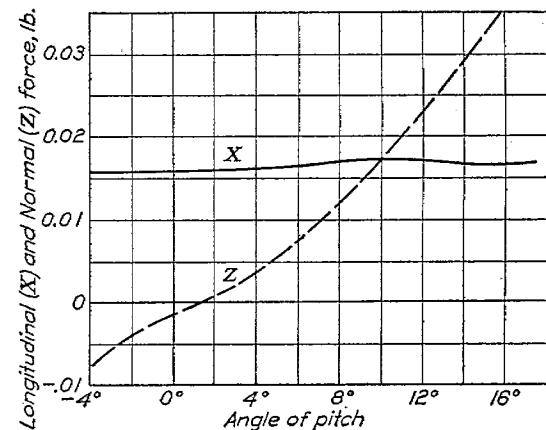
A9

0 1 2 3 4 5'



$$0^\circ \text{ pitch and yaw } S = .0870 \text{ sq. ft.}$$

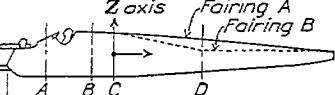
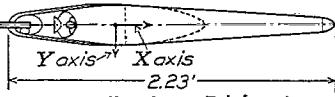
$V, f.p.s.$	40
$D, lb.$	.0443
$D/S, lb./sq.ft.$	.5100



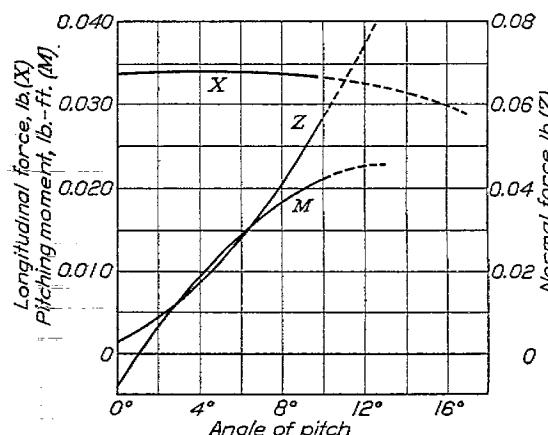
Forces and drag on model-seaplane fuselage. (Ref. R. and M. No. 199)

A10

0 1 2 3 4 5'

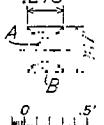
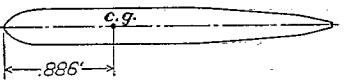


0° pitch and yaw	$V, f.p.s.$	40
Fairing "A"	$D, lb.$	.0331
	$D/S, lb./sq.ft.$	.4250
Fairing "B"	$D, lb.$	.0340
	$D/S, lb./sq.ft.$	.4360

Forces and moments in pitch on airplane fuselage F-E-7 model with fairing "A". $V=40$ f. p. s. (Ref. R. and M. No. 153)

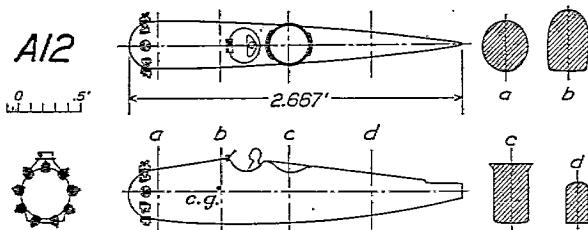
A11

0 1 2 3 4 5'



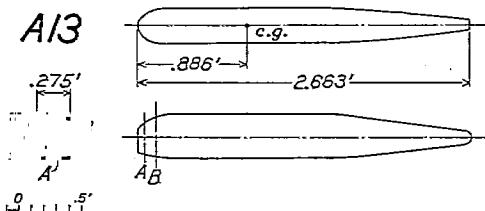
0° pitch and yaw	$S = .1012 \text{ sq. ft.}$
$V, f.p.s.$	35
$D, lb.$	.0256
$D/S, lb./sq.ft.$	.2530
$V, f.p.s.$	40
$D, lb.$	.0304
$D/S, lb./sq.ft.$	.3004
$V, f.p.s.$	50
$D, lb.$	.0466
$D/S, lb./sq.ft.$	.4605

Drag on an airplane fuselage, Bristol Pullman (B). (Ref. R. and M. No. 644)

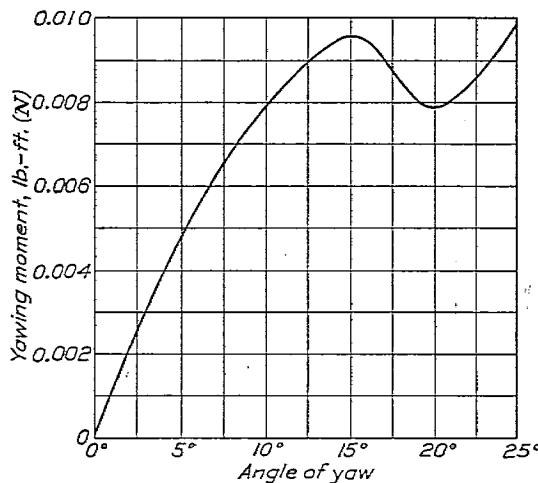


0° pitch and yaw	$V = 40 \text{ f.p.s.}$	$D = .0384 \text{ lb.}$
1, Body without eng., pilot or wind shield, all holes faired	-	-
2, (1) with pilot in place	-	$D = .0484 \text{ lb.}$
3, (2) " wind-shield in place	-	$D = .0609 \text{ lb.}$
4, Complete as shown, with engine	-	$D = .1540 \text{ lb.}$
5, " V, f.p.s.	44.0 58.7 73.3	88.0 102.7
Combination 1 D, lb.	44.0 237 365	500 .680
2 D/S, lb./sq.ft.	442 .783 1.200	1.718 2.235

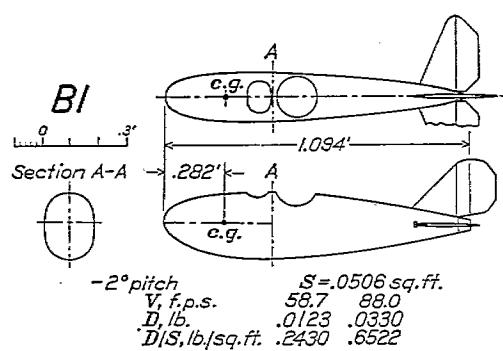
Drag on "Weasel" airplane fuselage. (Ref. R. and M. No. 465)



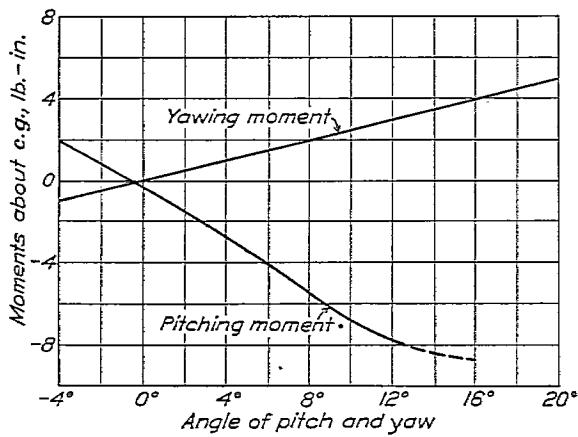
0° pitch and yaw	$S = .1012 \text{ sq.ft.}$
$V, \text{f.p.s.}$	35 40 50
$D, \text{lb.}$	.0276 .0315 .0482
$D/S, \text{lb./sq.ft.}$	.2727 .3113 .4763



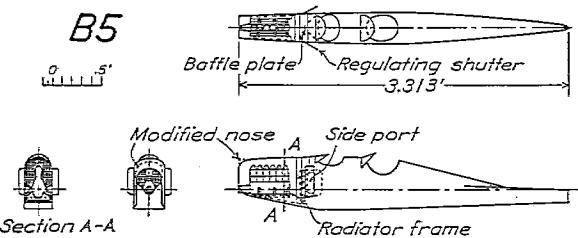
Yawing moment about c. g. of airplane fuselage of Bristol Pullman (A). $V=50 \text{ f.p.s.}$ (Ref. R. and M. No. 644)



-2° pitch	$S = .0506 \text{ sq.ft.}$
$V, \text{f.p.s.}$	58.7 88.0
$D, \text{lb.}$	.0123 .0330
$D/S, \text{lb./sq.ft.}$	.2430 .6522

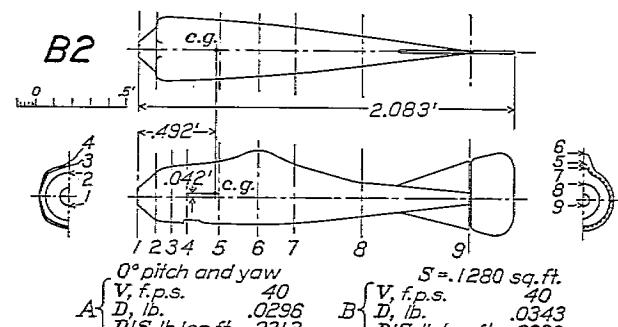


Moments about c. g. of Kirkham triplane-speed-scout fuselage. $V=58.7 \text{ f.p.s.}$ (Ref. W. T. R. No. 73)

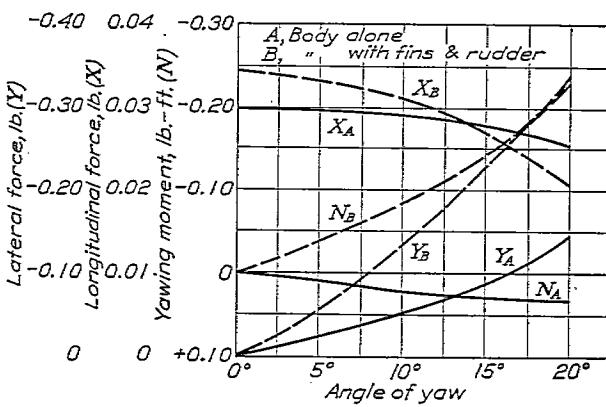


(A) Original model All openings closed,	$D = .1157 \text{ lb.}$	Inlet opening closed: $D = .1315 \text{ lb.}$
Side ports (only) closed,	$D = .1226 \text{ lb.}$	" " $D = .1698 \text{ lb.}$
(B) Modified model (square nose) Side ports open, shutters removed,	$D = .1508 \text{ lb.}$	$D = .1644 \text{ lb.}$
	$D = .1630 \text{ lb.}$	$D = .KSV^2, K = .00075, S = \text{sq.ft.}, V = \text{f.p.s.}$

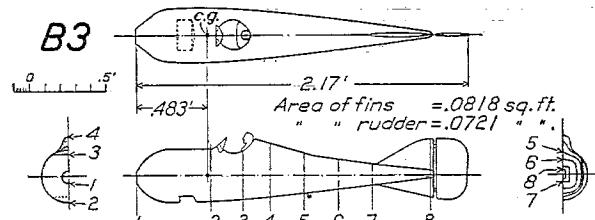
Drag on fuselage of RE-7 airplane with shutters. $V=40 \text{ f.p.s.}$ (Ref. R. and M. No. 221)



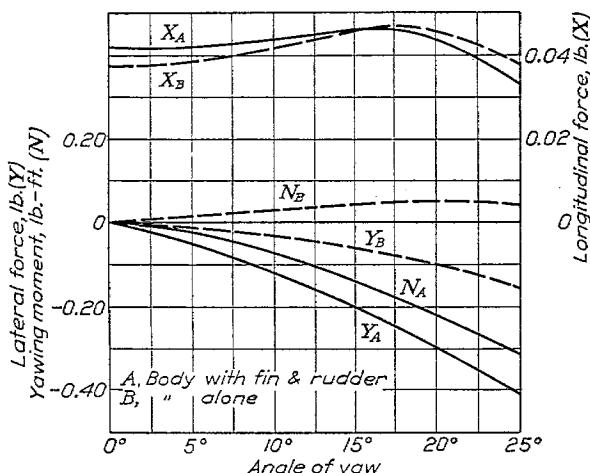
0° pitch and yaw	$S = .1280 \text{ sq.ft.}$
$V, \text{f.p.s.}$	40
$D, \text{lb.}$	.0296
$D/S, \text{lb./sq.ft.}$	.2313



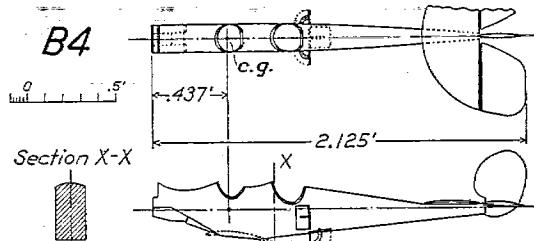
Forces and moment in yaw on fuselage of SE-4 airplane. $V=40 \text{ f.p.s.}$ (Ref. R. and M. No. 112)



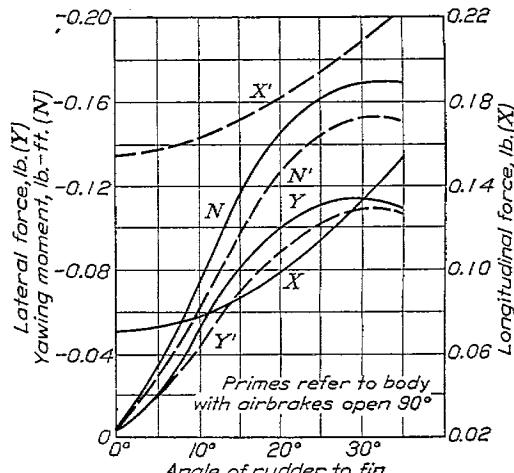
0° pitch and yaw $V = 40$ f.p.s. $S = .1032$ sq.ft.
Body with fin and rudder Body alone
 D , lb. .0417 D , lb. .0378
 D/S , lb./sq.ft. .4041 D/S , lb./sq.ft. .3663



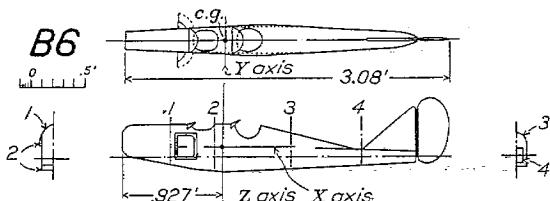
Forces and moments on fuselage of SE-4a airplane. $V = 40$ f.p.s. (Ref. R. and M. No. 153)



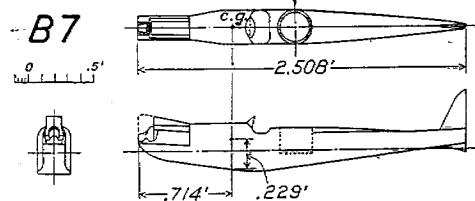
0° pitch and yaw $V = 40$ f.p.s. $S = .0510$ sq.ft.
Airbrakes closed Airbrakes open 90°
 D , lb. .0696 D , lb. .1550
 D/S , lb./sq.ft. 1.3647 D/S , lb./sq.ft. 3.0392



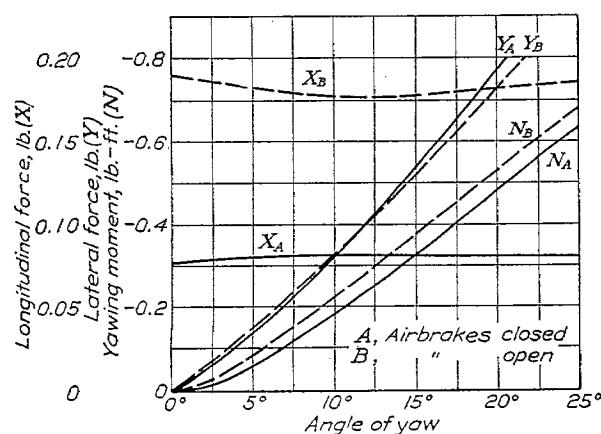
Forces and moments on fuselage of RE-1 airplane 0° pitch and yaw $V = 40$ f.p.s. (Ref. R. and M. No. 112)



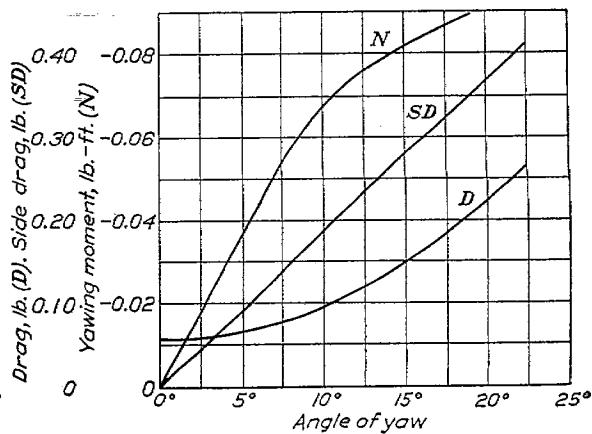
$S_f = .110$ sq.ft. (fin) $S_r = .160$ sq.ft. (rudder) $S = .0928$ sq.ft.
 0° pitch and yaw $V = 40$ f.p.s. With brakes, $S = .1578$ sq.ft.
Rudder neutral: Airbrakes closed. Airbrakes open. Airbrakes closed:
 D , lb. .0753 D , lb. .1882 D , lb. .0697
 D/S , lb./sq.ft. .814 D/S , lb./sq.ft. 1.193 D/S , lb./sq.ft. .7511



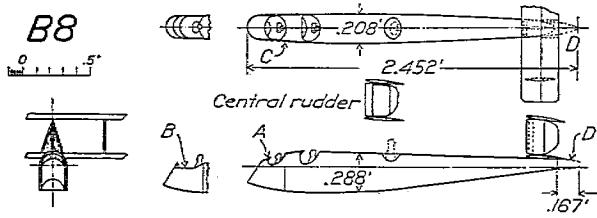
0° pitch and yaw. Body without fins. $S = .0913$ sq.ft.
 V , f.p.s. 40 50 60 70
 D , lb. .0685 .1060 .1540 .2150
 D/S , lb./sq.ft. .7503 1.1610 1.6867 2.3549



Forces and moments in yaw on RE-7 airplane fuselage fitted with fair-
brakes. $V = 40$ f.p.s. (Ref. R. and M. No. 153)

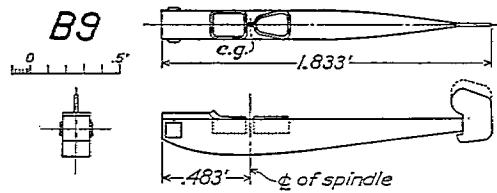


Forces and moments in yaw on RE-8 airplane fuselage with fins shown.
 $V = 40$ f.p.s. (Ref. R. and M. No. 201)

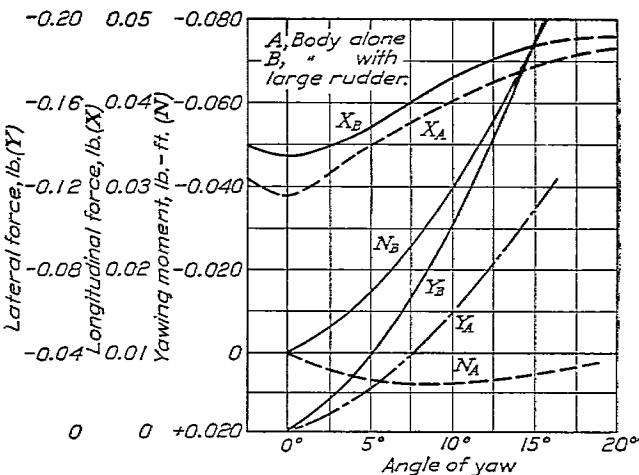


0° pitch and yaw $V = 40$ f.p.s. $S = .0560$ sq.ft.
Model as shown "A" $D = .0730$ lb., $D/S = 1.3036$ lb./sq.ft.
1, Body without stabilizers - $D = .0294$ lb., $D/S = .5250$ lb./sq.ft.
2, With cockpit "B" - $D = .0314$ lb., $D/S = .5607$ lb./sq.ft.
3, (I) With fairing "C" - $D = .0263$ lb., $D/S = .4696$ lb./sq.ft.
4, (I) " man in open cockpit" $D = .0394$ lb., $D/S = .7036$ lb./sq.ft.
5, (I) 3rd cockpit faired over $D = .0296$ lb., $D/S = .4804$ lb./sq.ft.
6, (I) With fairing "D" added - $D = .0265$ lb., $D/S = .4732$ lb./sq.ft.
Area of fixed fin = .0667 sq.ft. Area of central rudder = .035 sq.ft.
" outer rudders = .0425 sq.ft. Total fin area = .1442 sq.ft.

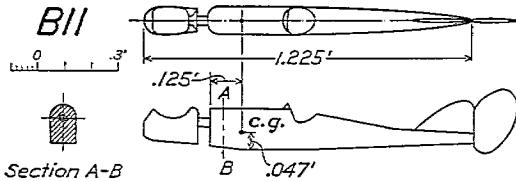
Drag on fuselage of FE-4 airplane. 0° pitch and yaw $V = 40$ f.p.s. (Ref. R. and M. No. 221)



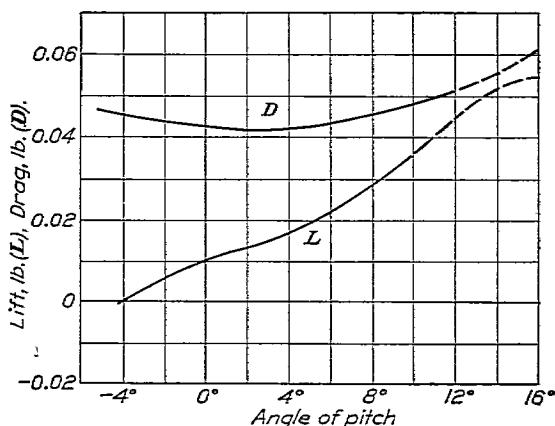
0° pitch and yaw $V = 40$ f.p.s. $S = .0390$ sq.ft.
With large rudder $D = .0287$ lb., $D/S = .40$ V, f.p.s. $.0287$
Body alone $D = .0332$ lb., $D/S = .40$ $D = .0287$ lb., $D/S = .7359$ lb./sq.ft.



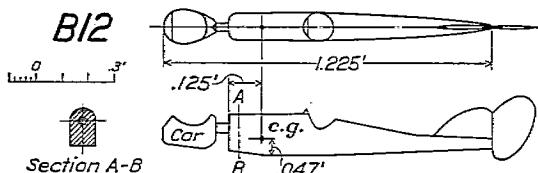
Forces and moments in yaw on fuselage of Avro seaplane. $V = 40$ f.p.s. (Ref. R. and M. No. 156)



Complete model $V = 40$ f.p.s. $S = .0520$ sq.ft.
Angle of pitch -2° $+3^\circ$ $+8^\circ$ $+13^\circ$
 D , lb. $.0850$ $.0650$ $.0710$ $.1120$
 D/S , lb./sq.ft. 1.6346 1.2500 1.3654 2.1538



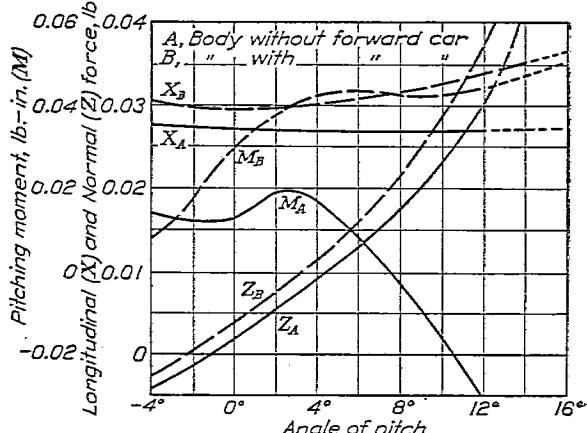
Lift and drag on fuselage only of BE-2c airplane. (Ref. R. and M. No. 254)



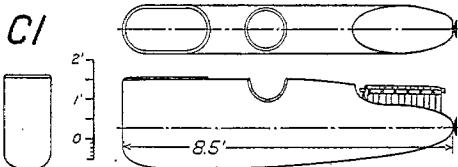
0° pitch and yaw $V = 40$ f.p.s. $S = .0935$ sq.ft.
Without car D , lb. $.0275$ With car D , lb. $.0352$
 D/S , lb./sq.ft. $.2941$ $.3765$

Drag with faired car on body of BE-9 airplane. (Ref. R. and M. No. 202)

0° pitch and yaw $V = 40$ f.p.s. $S = .0935$ sq.ft.
Without forward car D , lb. $.0275$ With forward car D , lb. $.0296$
 D/S , lb./sq.ft. $.2941$ $.3166$

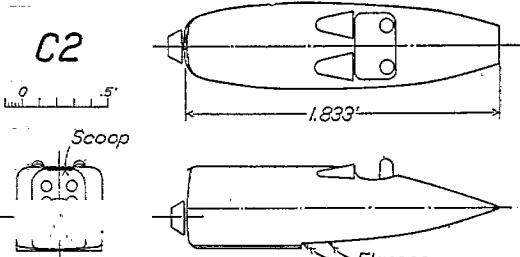


Forces and moments in pitch with unfaired car on fuselage of BE-9 airplane. $V = 40$ f.p.s. (Ref. R. and M. No. 202)

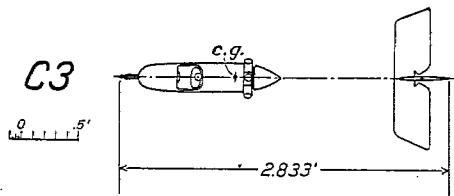


0° pitch and yaw
 V , f.p.s. 58.7 88.0 117.3 145.6
 D , lb. 3.7800 8.3500 14.7000 22.7000
 D/S , lb./sq.ft. 1.4538 3.2115 5.6538 8.7308

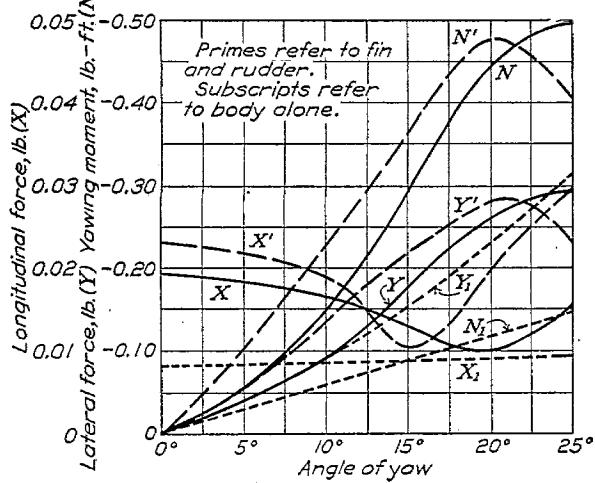
Drag on nacelle of Davis-gun seaplane. (Ref. W. T. R. No. 67)



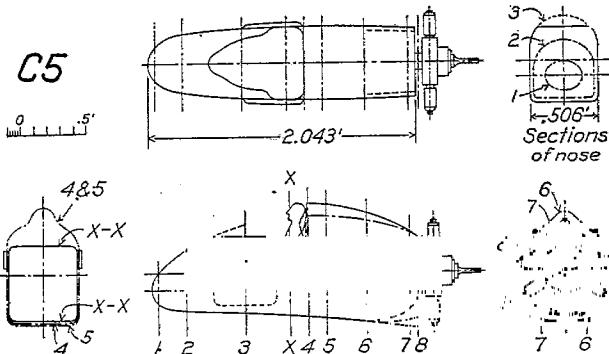
0° pitch and yaw $S = .258$ sq. ft.
 $V = 58.7$ f.p.s. $D = 1.883$ lb $D/S = .7298$ lb./sq.ft.



Body alone 0° pitch and yaw $S = .0910$ sq. ft. (approx.)
 $V = 40$ f.p.s. $D = .0848$ lb $D/S = .9315$ lb./sq.ft.

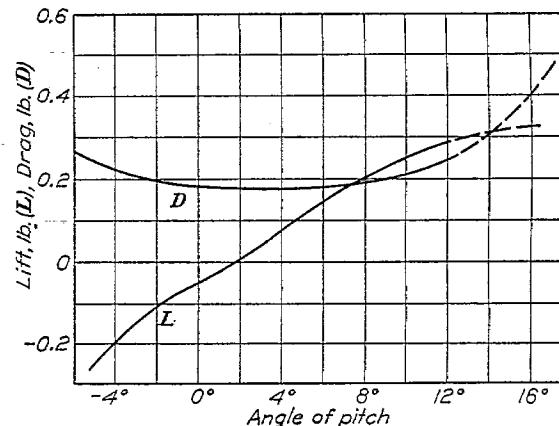


Forces and moments of fin and rudder. FE-8 airplane nacelle.
 $V = 40$ f.p.s. (Ref. R. and M. No. 156)

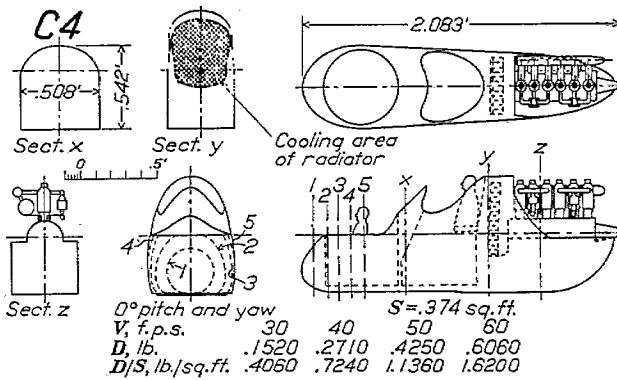


0° pitch and yaw $S = .4180$ sq. ft.
 V , f.p.s. 30 40 50 60
 D , lb. 1250 2180 3410 4900
 D/S , lb./sq.ft. 2990 5220 8150 11700

Drag on nacelle of FE-8 airplane. (Ref. R. and M. No. 305)

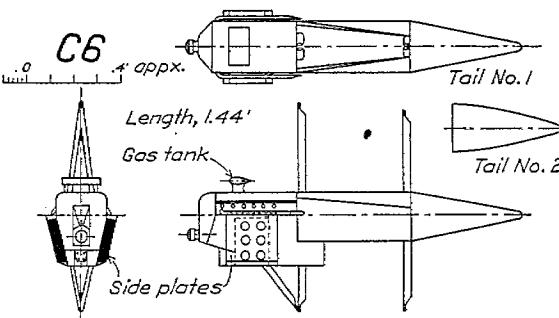


Lift and drag on nacelle of Richardson seaplane. $V = 58.7$ f.p.s.
(Ref. W. T. R. No. 54)



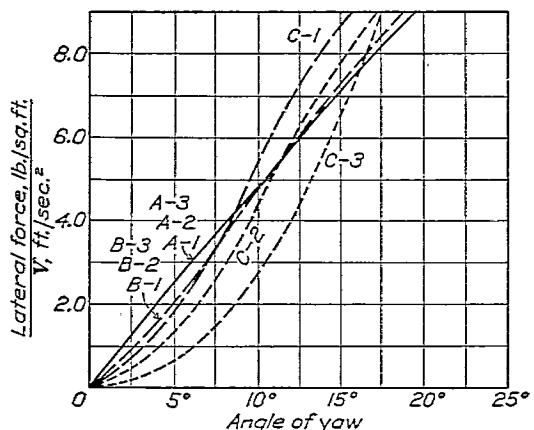
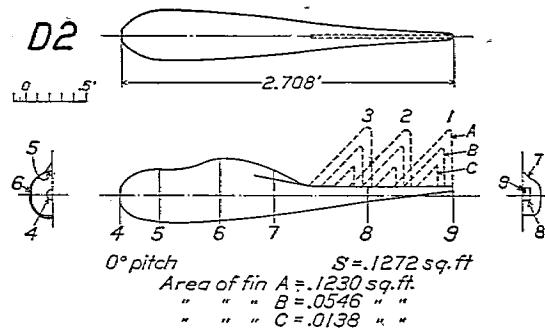
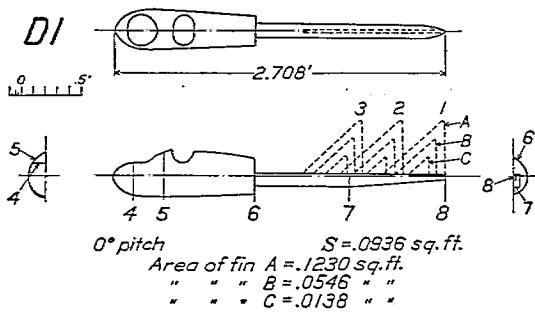
0° pitch and yaw
 V , f.p.s. 30 40 50 60
 D , lb. 1520 2710 4250 6060
 D/S , lb./sq.ft. 4060 .7240 1.1360 1.6200

Drag on nacelle of FE-2b airplane. (Ref. R. and M. No. 305)

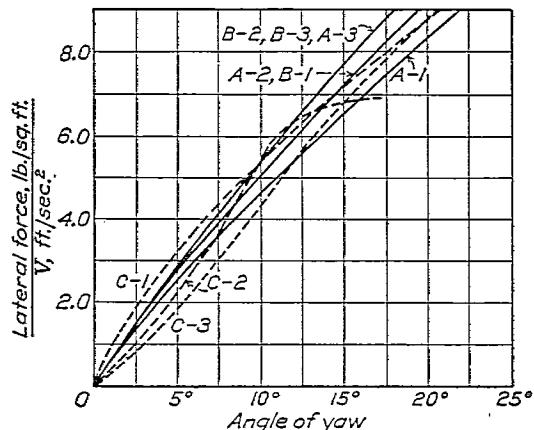


0° pitch and yaw $V = 40.0$ f.p.s.
No. 1 tail with radiators, $D = 1.120$ lb., without, $D = .0865$ lb.
No. 2 " " " ", $D = 1.151$ lb., " " $D = .0874$ lb.
Without tail, " " " ", $D = 1.210$ lb., " " $D = .1088$ lb.
Drag due to side plates, $D = .0103$ lb., gas tank, $D = .0072$ lb.

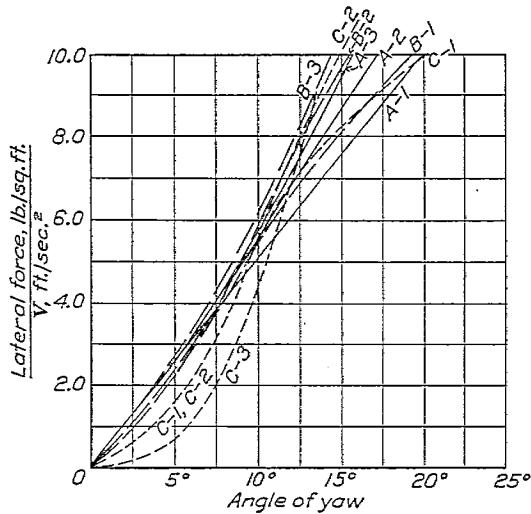
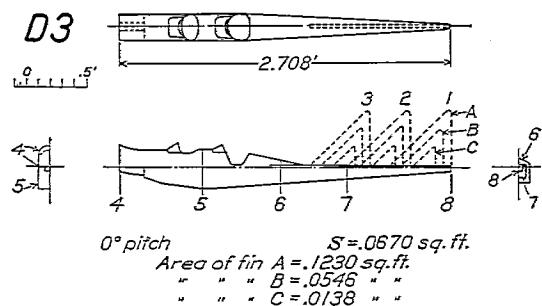
Drag on nacelle of Handley Page airplane. (Ref. R. and M. No. 251)



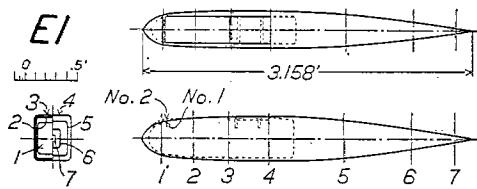
Lateral force on fin only of FE type fuselage. (Ref. R. and M. No. 201)



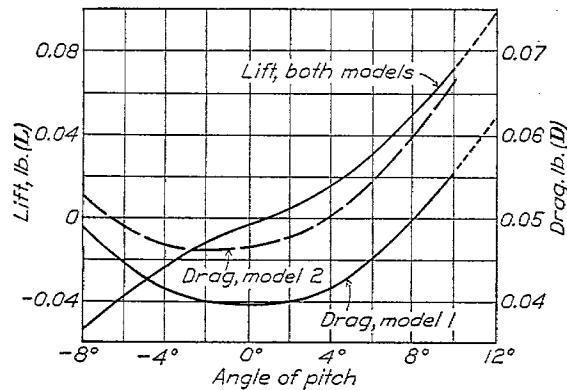
Lateral force on fin only of SE type fuselage. (Ref. R. and M. No. 201)



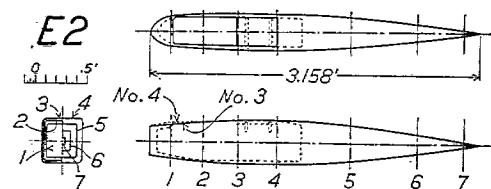
Lateral force on fin only of RE or Be type fuselage. (Ref. R. and M. No. 201)



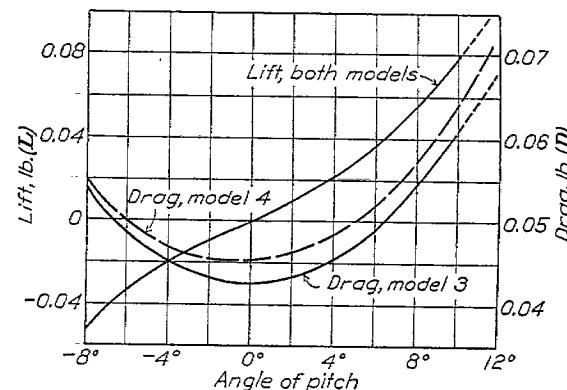
Model No. 1 Model No. 2
 $V, \text{f.p.s.}$ 40 $V, \text{f.p.s.}$ 40
 $D, \text{lb.}$.0395 $D, \text{lb.}$.0471
 $D/S, \text{lb./sq.ft.}$.2582 $D/S, \text{lb./sq.ft.}$.3078



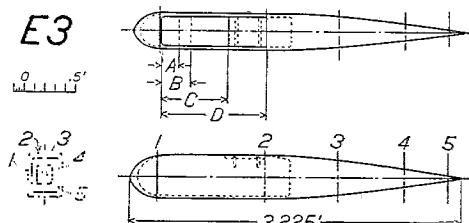
Lift and drag on H. M. A. "Epsilon" airship car, models Nos. 1 and 2



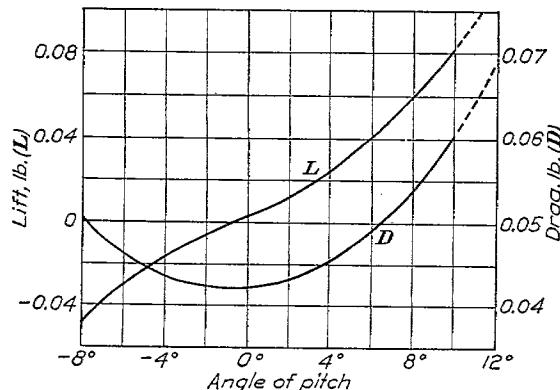
Model No. 3 Model No. 4
 $V, \text{f.p.s.}$ 40 $V, \text{f.p.s.}$ 40
 $D, \text{lb.}$.0426 $D, \text{lb.}$.0455
 $D/S, \text{lb./sq.ft.}$.2784 $D/S, \text{lb./sq.ft.}$.2974



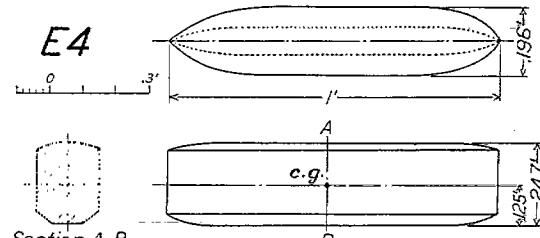
Lift and drag on H. M. A. "Epsilon" airship car, models Nos. 3 and 4



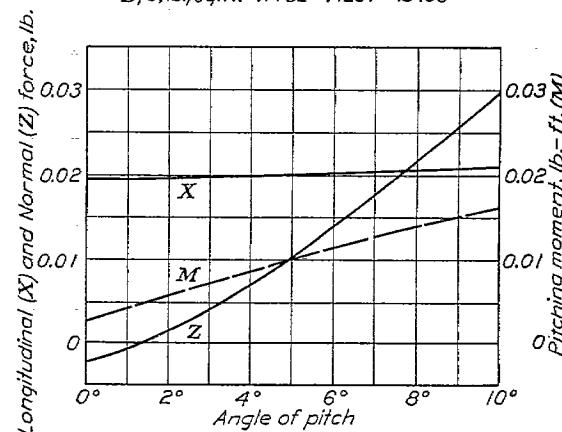
0° pitch and yaw $V, 40 \text{ f.p.s.}$ $S = .150 \text{ sq.ft.}$
 Opening None A B C D
 $D, \text{lb.}$.0424 .0446 .0461 .0528 .0461
 $D/S, \text{lb./sq.ft.}$.2827 .2973 .3037 .3520 .3073



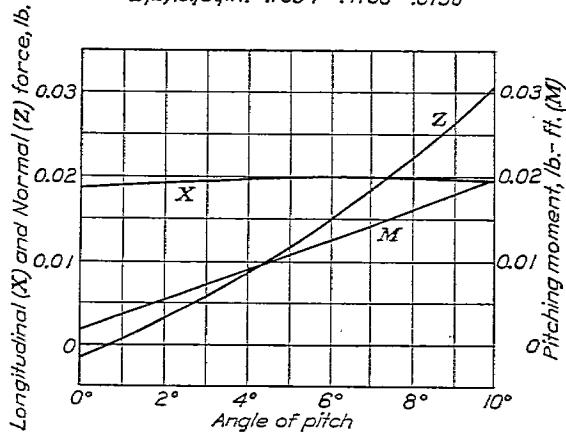
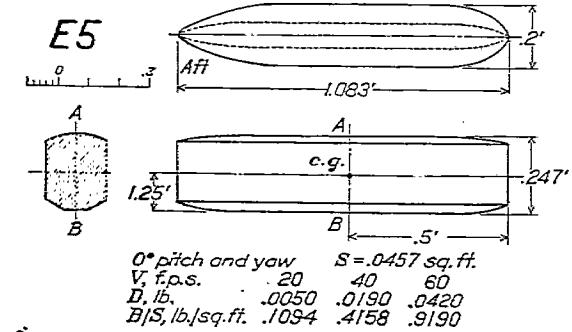
Lift and drag on H. M. A. "Epsilon" airship car. (Ref. R. and M. No. 108)



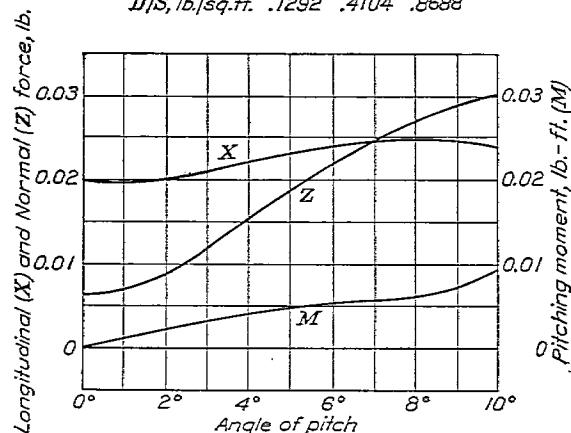
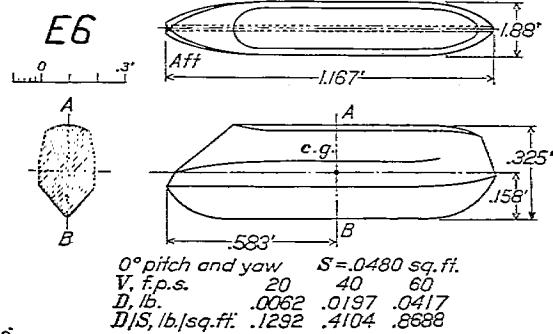
0° pitch and yaw $V, \text{f.p.s.}$ 20 40 60
 $D, \text{lb.}$.0054 .0192 .0432
 $D/S, \text{lb./sq.ft.}$.1182 .4201 .9453



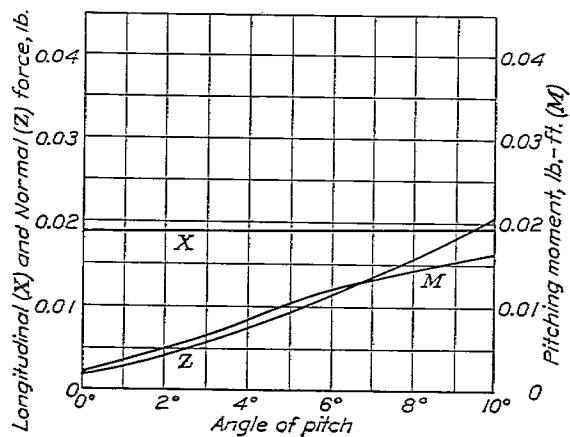
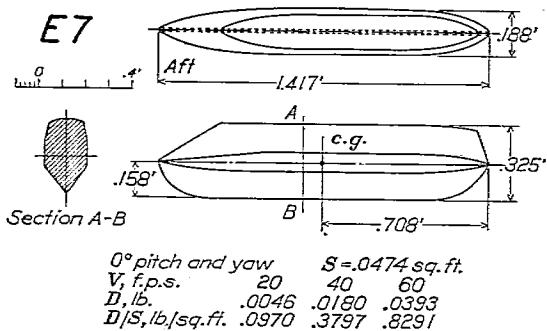
Forces and moments in pitch on airship car "A." (Ref. R. and M. No. 151)



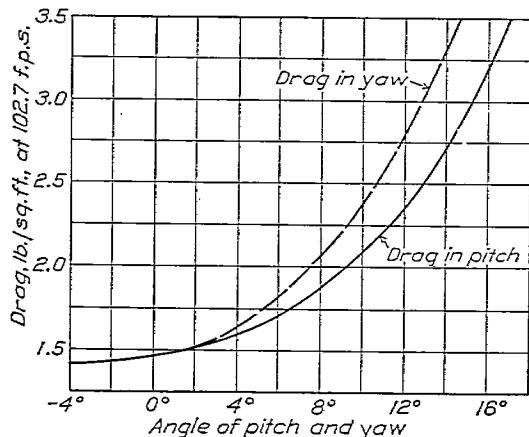
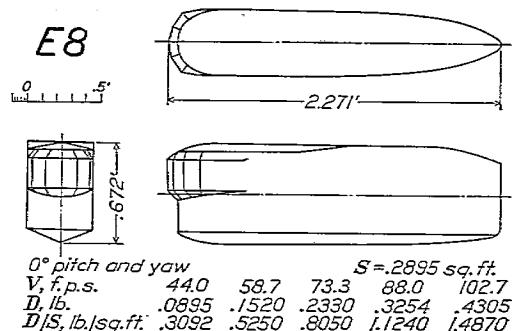
Forces and moments in pitch on airship car "B." (Ref. R. and M. No. 151)



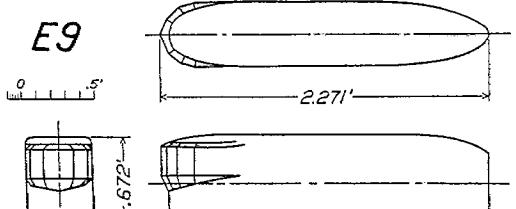
Forces and moments in pitch on airship car "C." (Ref. R. and M. No. 151)



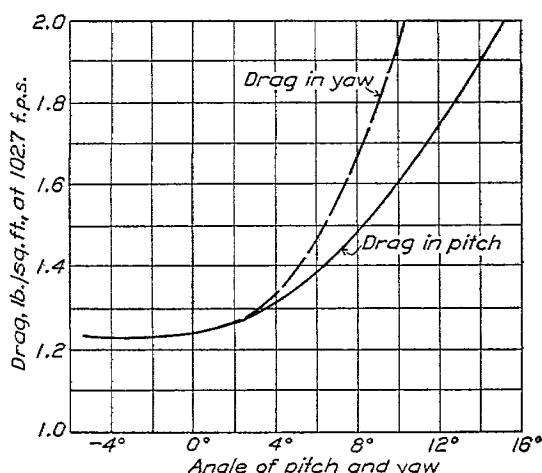
Forces and moments in pitch on airship car "D." Ref. R. and M. No. 151)



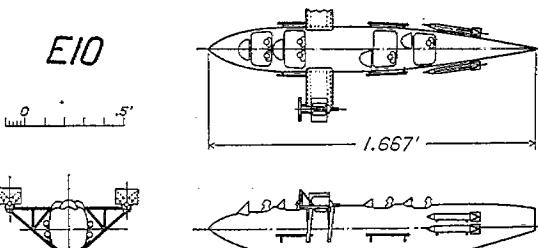
Drag on closed airship car, model No. 326. (Ref. W. T. R. No. 145)



0° pitch and yaw $S = .3034 \text{ sq. ft.}$
 $V, \text{f.p.s.} \quad 44.0 \quad 58.7 \quad 73.3 \quad 88.0 \quad 102.7$
 $D, \text{lb.} \quad .0783 \quad .1314 \quad .2005 \quad .2816 \quad .3705$
 $D/S, \text{lb./sq.ft.} \quad .2580 \quad .4330 \quad .6610 \quad .9230 \quad 1.2210$

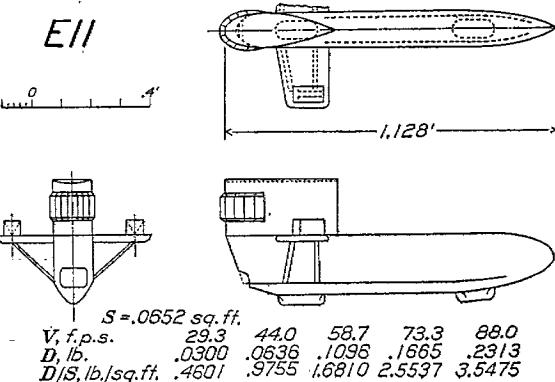


Drag on closed airship car, model No. 325. (Ref. W. T. R. No. 145)



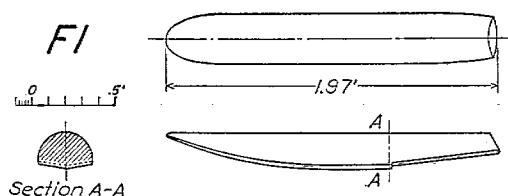
0° pitch and yaw $S = .0630 \text{ sq. ft.}$
 $V, \text{f.p.s.} \quad 29.3 \quad 44.0 \quad 58.7 \quad 73.3 \quad 88.0$
 $D, \text{lb.} \quad .0468 \quad .1040 \quad .1835 \quad .2834 \quad .3996$
 $D/S, \text{lb./sq.ft.} \quad .7429 \quad 1.6508 \quad 1.9127 \quad 4.4984 \quad 6.3429$
Values for model as shown with bombs and appendages

Drag on "C" class car. (Ref. W. T. R. No. 140)

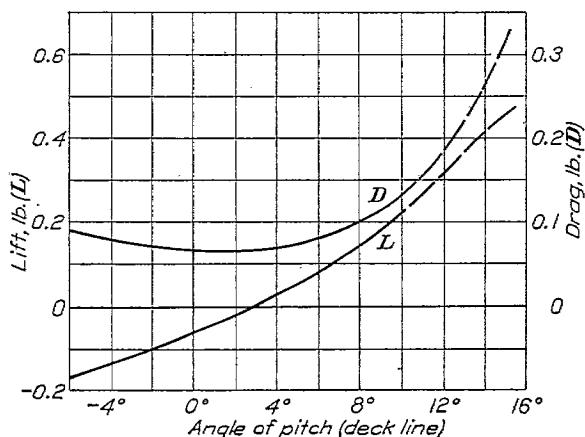


$S = .0652 \text{ sq. ft.}$
 $V, \text{f.p.s.} \quad 29.3 \quad 44.0 \quad 58.7 \quad 73.3 \quad 88.0$
 $D, \text{lb.} \quad .0300 \quad .0636 \quad .1095 \quad .1665 \quad .2313$
 $D/S, \text{lb./sq.ft.} \quad .4601 \quad .9795 \quad 1.6810 \quad 2.5537 \quad 3.5475$

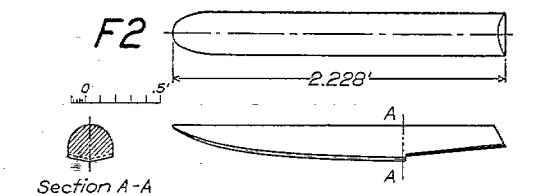
Drag on "G" class car. (Ref. W. T. R. No. 140)



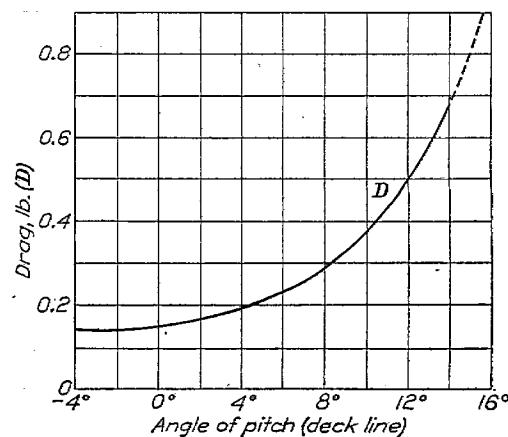
0° pitch and yaw $S = .0751 \text{ sq. ft.}$
 $V, \text{f.p.s.} \quad 44.0 \quad 58.7 \quad 73.3 \quad 88.0$
 $D, \text{lb.} \quad .0366 \quad .0627 \quad .0963 \quad .1390$
 $D/S, \text{lb./sq.ft.} \quad .4874 \quad .8349 \quad 1.2823 \quad 1.8509$



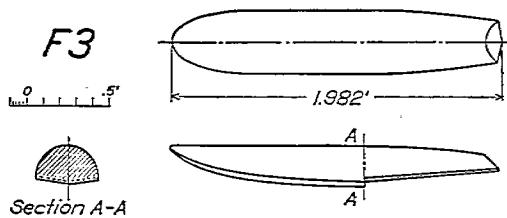
Lift and drag on Speed Scout seaplane float. $V=58.7 \text{ f.p.s.}$ (Ref. W. T. R. No. 18)



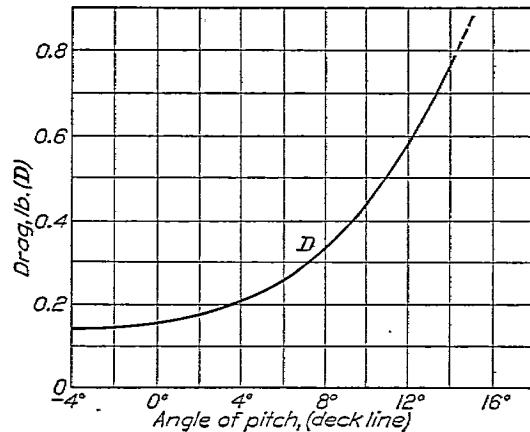
0° pitch and yaw $S = .0554 \text{ sq. ft.}$
 $V, \text{f.p.s.} \quad 44.0 \quad 58.7 \quad 73.3 \quad 88.0$
 $D, \text{lb.} \quad .0394 \quad .0681 \quad .1063 \quad .1495$
 $D/S, \text{lb./sq.ft.} \quad .7110 \quad 1.2270 \quad 1.9180 \quad 2.6986$



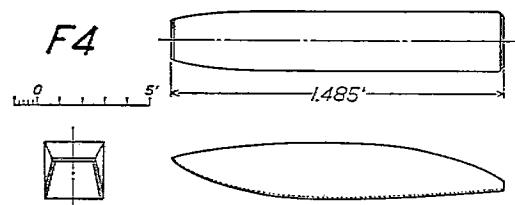
Drag on Speed Scout seaplane float. $V=88 \text{ f.p.s.}$ (Ref. W. T. R. No. 147)



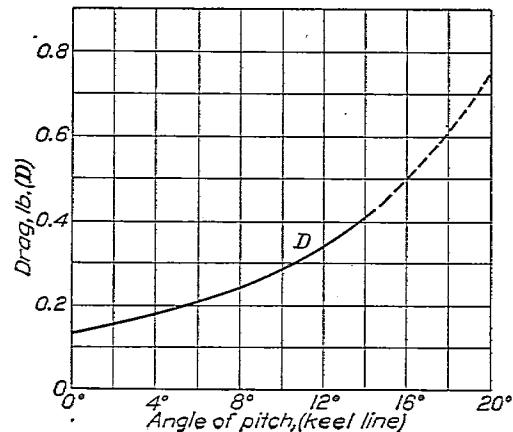
0° pitch and yaw $S = .0751 \text{ sq.ft.}$
 $V, \text{ f.p.s.} \quad 44.0 \quad 58.7 \quad 73.3 \quad 88.0$
 $D, \text{ lb.} \quad .0423 \quad .0720 \quad .1129 \quad .1613$
 $D/S, \text{ lb./sq.ft.} \quad .5632 \quad .9587 \quad 1.5033 \quad 2.1478$



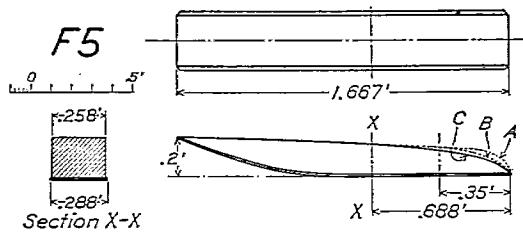
Drag on N-9 seaplane float. $V=88 \text{ f.p.s.}$ (Ref. W.T.R. No. 147)



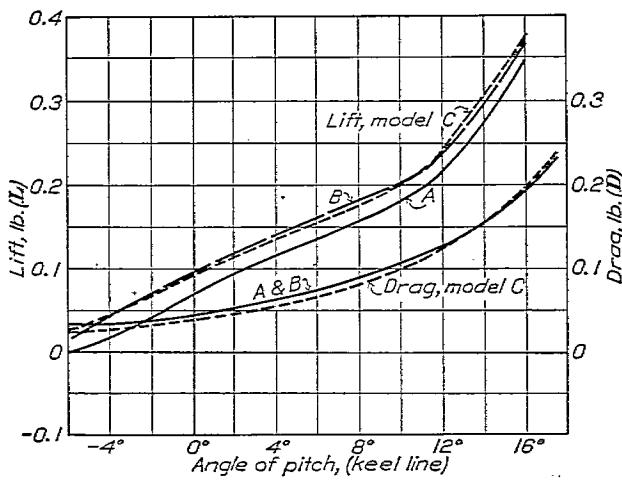
0° pitch and yaw $S = .0729 \text{ sq.ft.}$
 $V, \text{ f.p.s.} \quad 44.0 \quad 58.7 \quad 73.3 \quad 88.0$
 $D, \text{ lb.} \quad .0339 \quad .0596 \quad .0923 \quad .1318$
 $D/S, \text{ lb./sq.ft.} \quad .4650 \quad .8176 \quad 1.2661 \quad 1.8080$



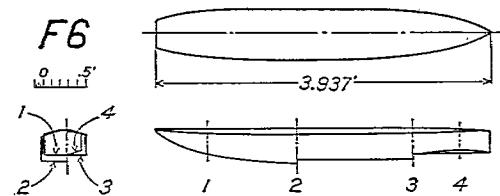
Drag on Sopwith seaplane float. $V=88 \text{ f.p.s.}$ (Ref. W.T.R. No. 147)



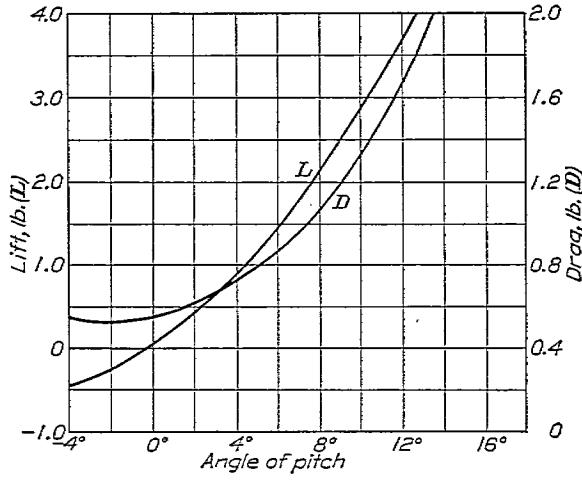
0° pitch and yaw $V=40 \text{ f.p.s.} \quad S = .0456 \text{ sq.ft.}$
Model A B C
 $D, \text{ lb.} \quad .0443 \quad .0458 \quad .0406$
 $D/S, \text{ lb./sq.ft.} \quad .9715 \quad 1.0044 \quad .8904$



Lift and drag on seaplane float. $V=58.7 \text{ f.p.s.}$ (R. and M. No. 199)

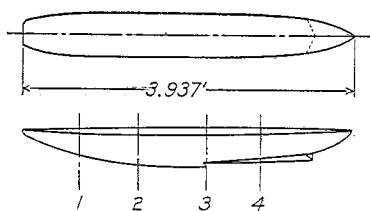


0° pitch and yaw $S = .2326 \text{ sq.ft.}$
 $V, \text{ f.p.s.} \quad 98.6$
 $D, \text{ lb.} \quad .5560$
 $D/S, \text{ lb./sq.ft.} \quad 2.39$

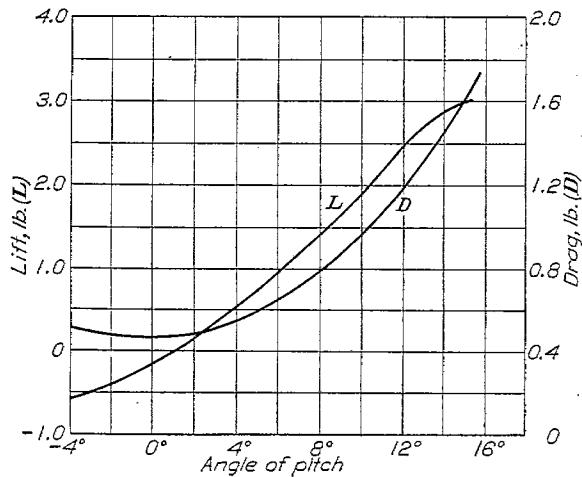


Lift and drag on Göttingen No. 1 float. $V=98.6 \text{ f.p.s.}$ (Ref. Göttingen 1921)

F7
0
1
2
3
4

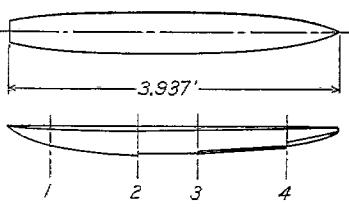


0° pitch and yaw $S = .2160 \text{ sq.ft.}$
 $V, \text{ f.p.s.} \quad 98.6$
 $D, \text{ lb.} \quad 0.456$
 $D/S, \text{ lb./sq.ft.} \quad 2.111$

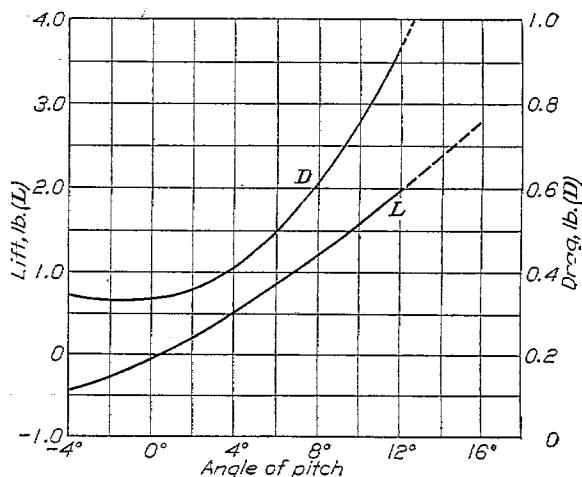


Lift and drag on Göttingen No. 2 float. $V=98.6 \text{ f.p.s.}$ (Ref.
Göttingen 1921)

F8
0
1
2
3
4

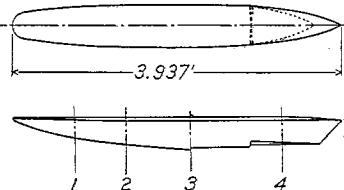


0° pitch and yaw $S = .1525 \text{ sq.ft.}$
 $V, \text{ f.p.s.} \quad 98.6$
 $D, \text{ lb.} \quad 0.330$
 $D/S, \text{ lb./sq.ft.} \quad 2.164$

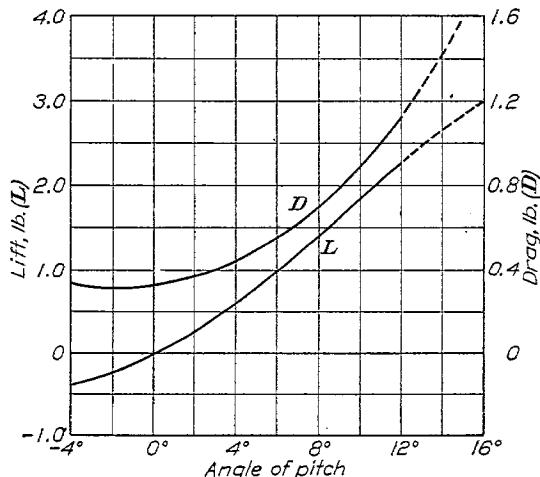


Lift and drag on Göttingen No. 3 float. $V=98.6 \text{ f.p.s.}$ (Ref.
Göttingen 1921)

F9
0
1
2
3
4

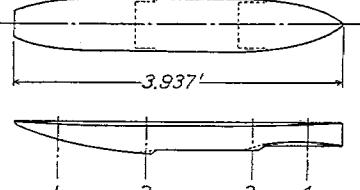


0° pitch and yaw $S = .1940 \text{ sq.ft.}$
 $V, \text{ f.p.s.} \quad 98.6$
 $D, \text{ lb.} \quad 0.366$
 $D/S, \text{ lb./sq.ft.} \quad 1.887$

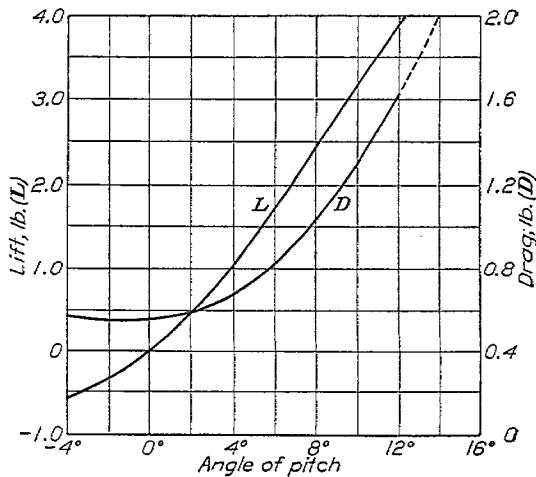


Lift and drag on Göttingen No. 4 float. $V=98.6 \text{ f.p.s.}$ (Ref.
Göttingen 1921)

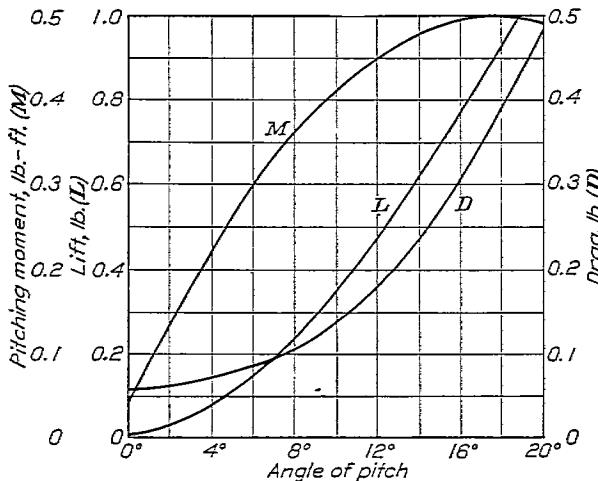
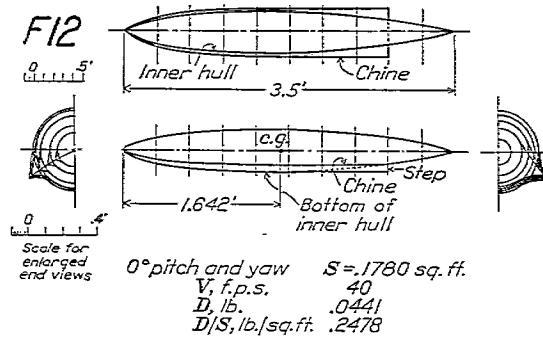
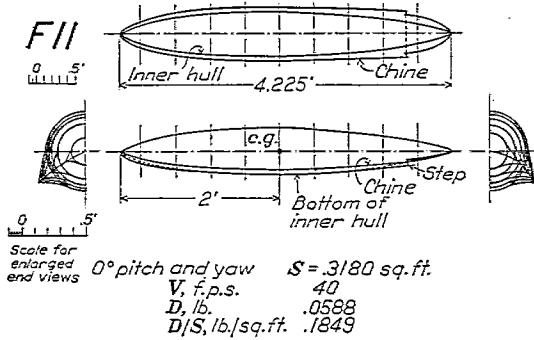
F10
0
1
2
3
4



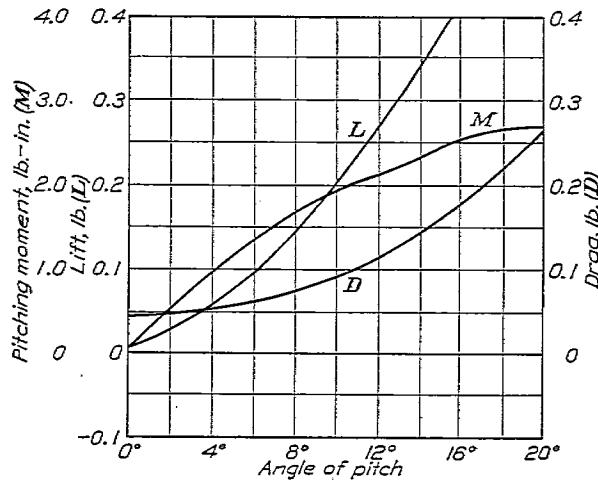
0° pitch and yaw $S = .2255 \text{ sq.ft.}$
 $V, \text{ f.p.s.} \quad 97.5$
 $D, \text{ lb.} \quad .5520$
 $D/S, \text{ lb./sq.ft.} \quad 2.45$



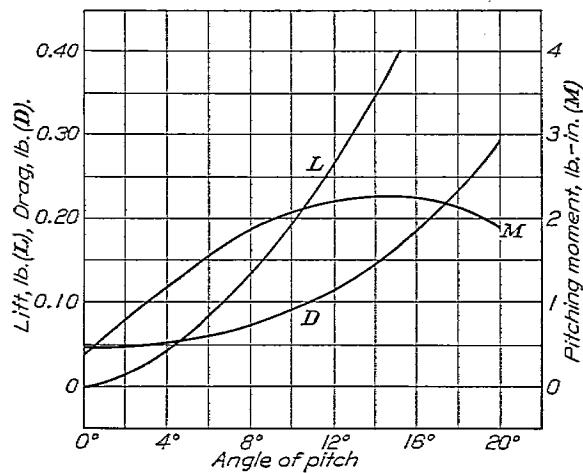
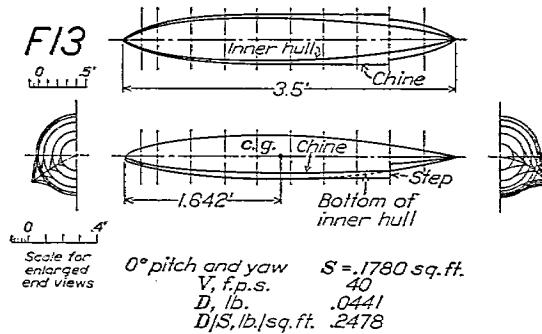
Lift and drag on Göttingen No. 5 float. $V=97.5 \text{ f.p.s.}$ (Ref.
Göttingen 1921)



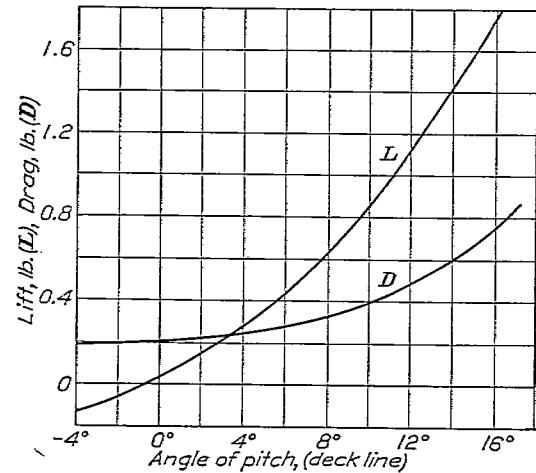
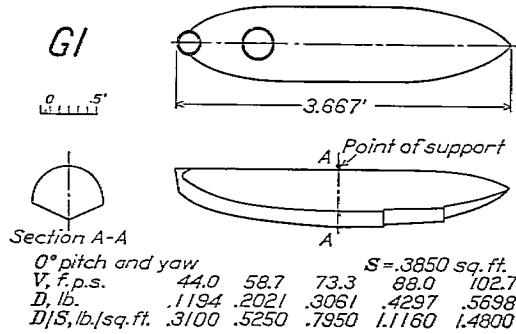
Forces and moments in pitch on an A. D. main float for short sea-planes. $V=40$ f. p. s. (Ref. R. and M. No. 285)



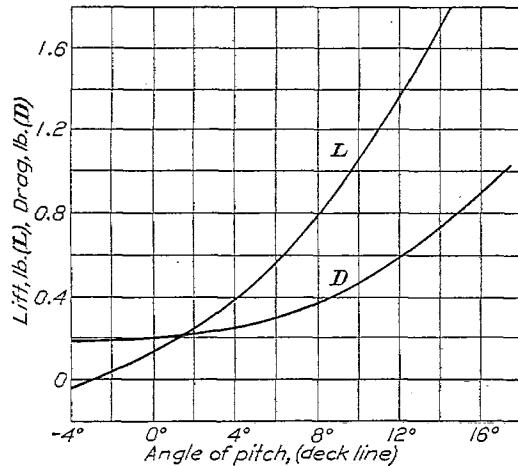
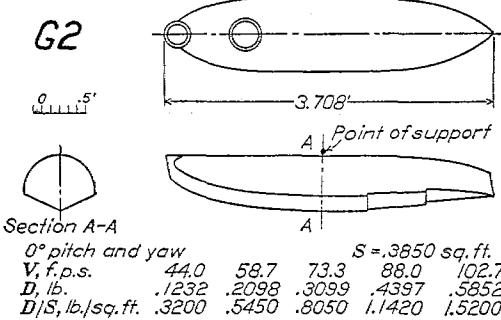
Forces and moments in pitch on a Blackburn seaplane main float No. 2. $V=40$ f. p. s. (Ref. R. and M. No. 285)



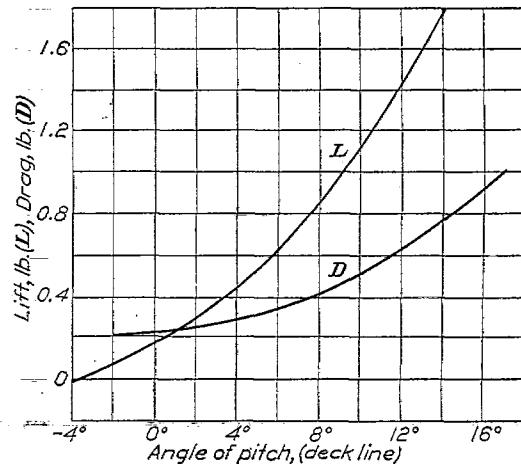
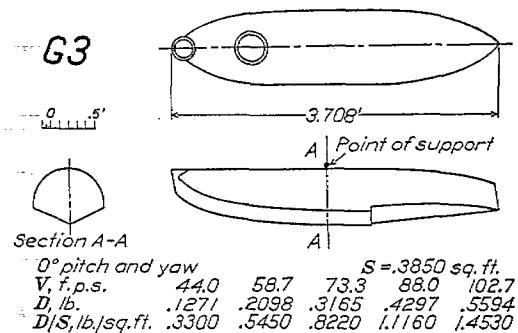
Forces and moments in pitch on a Blackburn seaplane main float No. 1. $V=40$ f. p. s. (Ref. R. and M. No. 285)



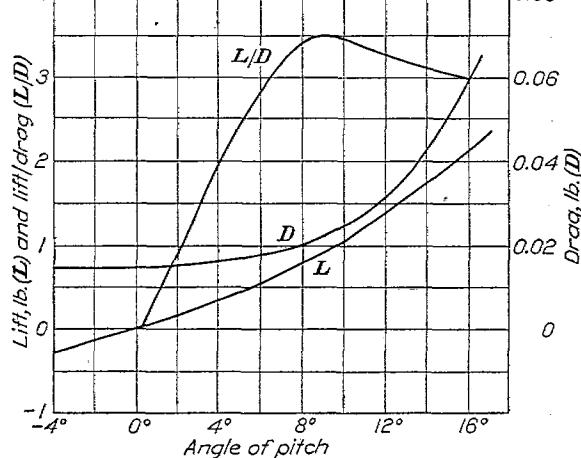
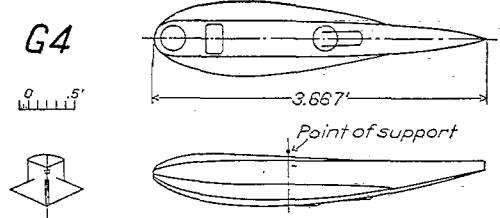
Lift and drag on NC-1 hull, stern No. 1. $V=53.7$ f. p. s. (Ref. W. T. R. No. 64)



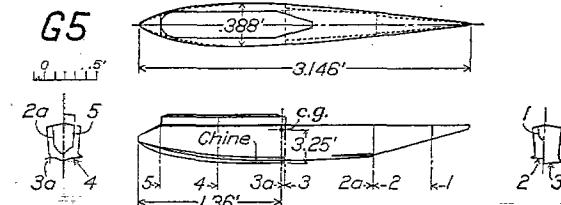
Lift and drag on NC-1 hull, stern No. 2. $V=58.7$ f. p. s. (Ref. W. T. R. No. 64)



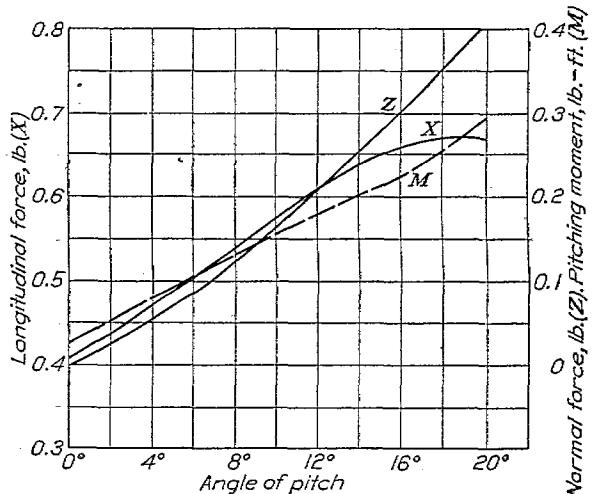
Lift and drag on NC-1 hull, stern No. 3. $V=58.7$ f. p. s. (Ref. W. T. R. No. 64)



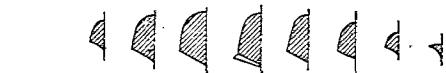
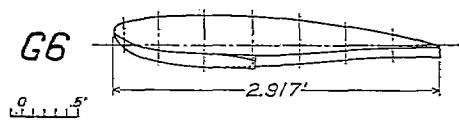
Lift and drag on F-5-L seaplane hull. $V=58.7$ f. p. s. (Ref. W. T. R. No. 83)



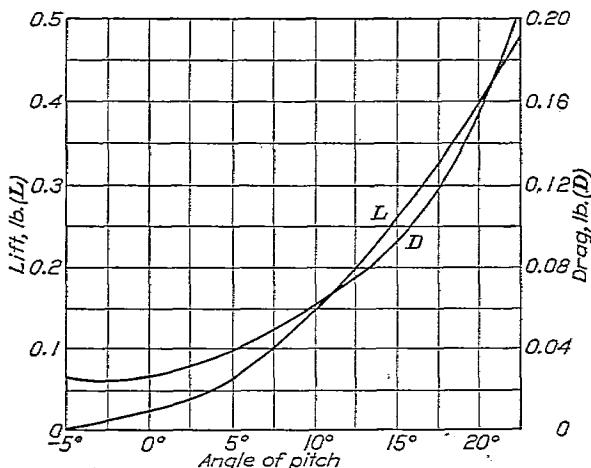
0° pitch and yaw $S = .1400 \text{ sq. ft.}$
 $V, \text{f.p.s.} \quad 40 \quad 50 \quad 60 \quad 70 \quad 80$
 $D, \text{lb.} \quad 0413 \quad 0662 \quad 0953 \quad 1283 \quad 1650$
 $D/S, \text{lb./sq.ft.} \quad 2950 \quad 4730 \quad 6810 \quad 9164 \quad 11780$



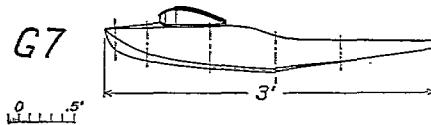
Forces and moments in pitch on hull. $V=40$ f. p. s. (Ref. R. and M. No. 223)



0° pitch and yaw $S = .1700 \text{ sq.ft.}$
 $V, \text{ f.p.s.}$ 30 40 50 60 70 80
 $D, \text{ lb.}$.0273 .0445 .0645 .0877 .1130
 $D/S, \text{ lb./sq.ft.}$.1608 .2618 .3794 .5159 .6647

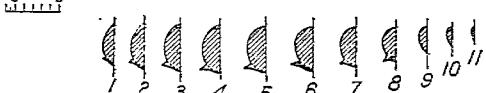
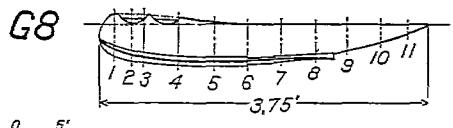


Lift and drag on R. A. E. seaplane hull. $V=40 \text{ f.p.s.}$ (Ref. R. and M. No. 461)



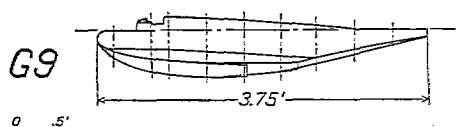
0° pitch and yaw $S = .257 \text{ sq.ft.}$
 $V, \text{ f.p.s.}$ 30 40 50 60 70 80
 $D, \text{ lb.}$.0428 .0822 .1264 .1810 .2478 .3233
 $D/S, \text{ lb./sq.ft.}$.1655 .3198 .4918 .7043 .9842 1.2580
Without cabin $S = .184 \text{ sq.ft.}$
 $D, \text{ lb.}$.0300 .0505 .0775 .1111 .1502 .1976
 $D/S, \text{ lb./sq.ft.}$.1630 .2745 .4212 .6038 .8163 1.0739

Drag on NT-2B seaplane hull. (Ref. R. and M. No. 461)



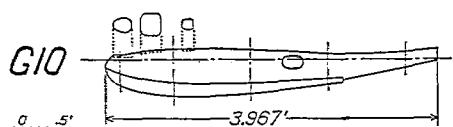
0° pitch and yaw $S = .186 \text{ sq.ft.}$
 $V, \text{ f.p.s.}$ 30 40 50 60 70 80
 $D, \text{ lb.}$.0279 .0475 .0715 .1011 .1381 .1810
 $D/S, \text{ lb./sq.ft.}$.1500 .2554 .3844 .5435 .7425 .9731

Drag on 30-foot A. D. seaplane hull. (Ref. R. and M. No. 461)



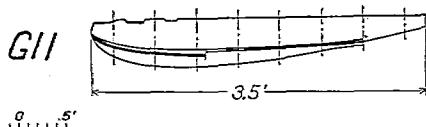
0° pitch and yaw $S = .2760 \text{ sq.ft.}$
 $V, \text{ f.p.s.}$ 30 40 50 60 70 80
 $D, \text{ lb.}$.0414 .0711 .1108 .1562 .2130 .2895
 $D/S, \text{ lb./sq.ft.}$.1500 .2576 .4014 .5659 .7717 .9764

Drag on F-3 seaplane hull. (Ref. R. and M. No. 461)



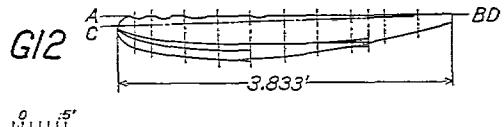
0° pitch and yaw $S = .2520 \text{ sq.ft.}$
 $V, \text{ f.p.s.}$ 30 40 50 60 70 80
 $D, \text{ lb.}$.0313 .0532 .0821 .1171 .1591 .2051
 $D/S, \text{ lb./sq.ft.}$.1242 .2111 .3258 .4647 .6313 .8139

Drag on N-4A seaplane hull. (Ref. R. and M. No. 461)



0° pitch and yaw $S = .297 \text{ sq.ft.}$
 $V, \text{ f.p.s.}$ 30 40 50 60 70 80
 $D, \text{ lb.}$.0285 .0488 .0750 .1071 .1449 .1880
 $D/S, \text{ lb./sq.ft.}$.1203 .2059 .3165 .4519 .6114 .7932

Drag on N-4 seaplane hull. (Ref. R. and M. No. 461)



0° pitch and yaw $S = .207 \text{ sq.ft.}$
 $V, \text{ f.p.s.}$ 30 40 50 60 70 80
Line AB parallel to wind .0329 .0588 .0903 .1284 .1733 .2253
 $D, \text{ lb.}$.1589 .2841 .4362 .6203 .8372 1.0884
Line CB parallel to wind .0367 .0635 .0978 .1397 .1853 .2420
 $D/S, \text{ lb./sq.ft.}$.1773 .3068 .4725 .6749 .8952 1.1691

Drag on P-5A seaplane hull. (Ref. R. and M. No. 461)

